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DISEASE FACTORS IN STENELLA
ATTENUATA AND STENELLA LONGIROSTRIS
TAKEN IN THE EASTERN TROPICAL PACIFIC
YELLOWFIN TUNA PURSE SEINE FISHERY

BY

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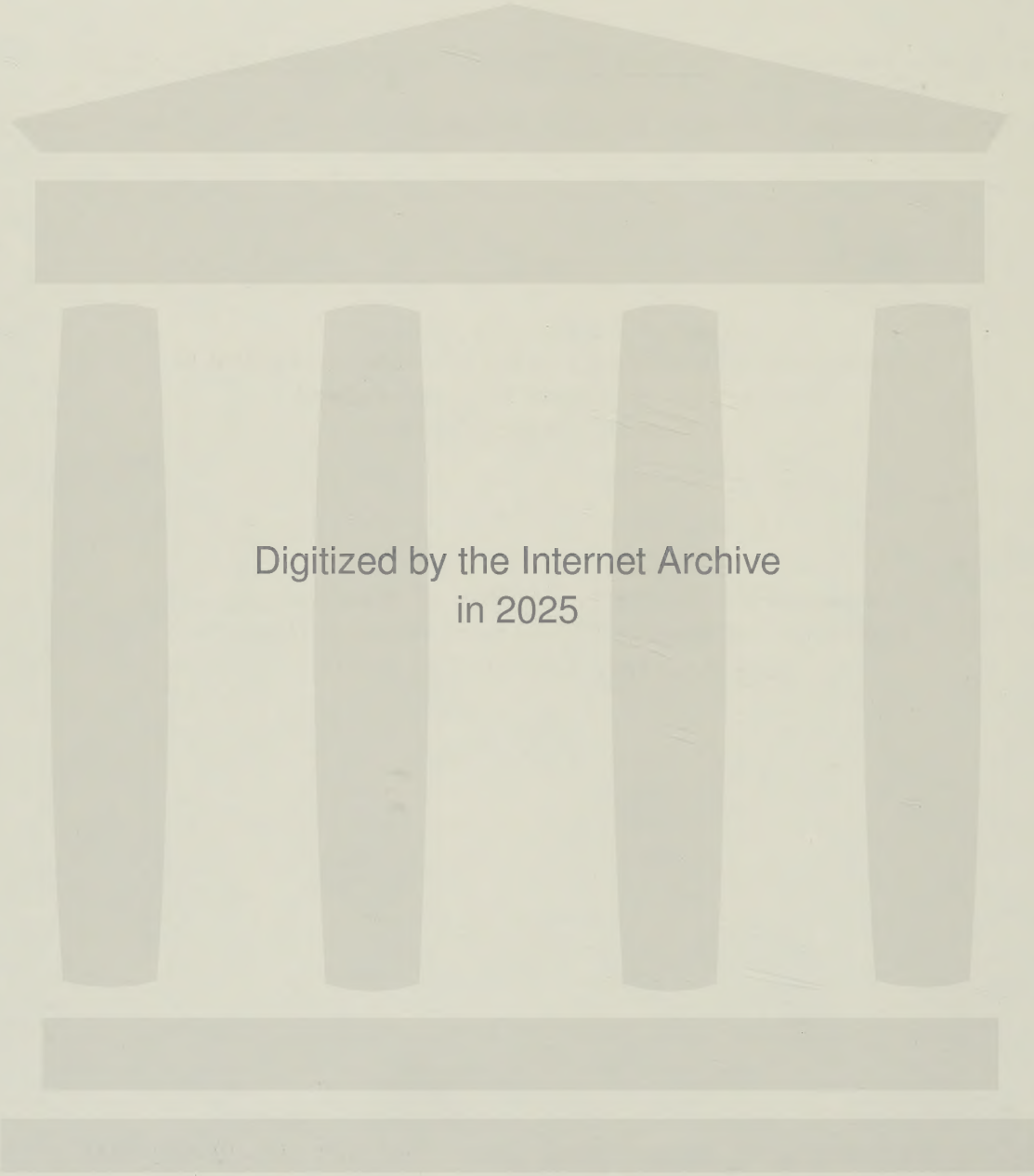
Taken in the Eastern Tropical Pacific Yellowfin Tuna Purse Seine Fishery

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INTRODUCTION

Each year thousands of spotter porpoise (Stenella attenuata) and spinner porpoise (Stenella longirostris) are incidentally killed in the purse seine fishery for yellowfin tuna in the eastern tropical Pacific (Perrin 1969 and 1970a). The number lost per year has been reduced from an estimated 309,000 animals in 1972 to 27,000 in 1977 (Powers et al, 1979). What is not known is if porpoise captured and released during the course of the purse seine fishing are impaired in some way that may cause them to succumb unseen and uncounted; i. e., whether an unknown mortality occurs in addition to the readily observable immediate mortality which takes place within the confines of the net. In addition to the potential effects of debilitating pathologic conditions related directly to the fishery, a study of the effects of naturally occurring disease and disease mechanisms was needed to provide background information on natural mortality and reproductive viability in free-ranging porpoise populations.

In order to address these questions, we participated in two 50 day cruises aboard the commercial tuna seiner Queen Mary in the 1978 Dedicated Vessel Program. This program was a cooperative tuna/research effort under the joint direction of the Marine Mammal Commission, National Marine Fisheries Service, and United States Tuna Foundation.

We participated in dedicated vessel Cruise II (April 17 - June 5, 1978) and Cruise IV (September 12 - October 31, 1978). Southwest Fisheries Center had devised unique gear, the porpoise school impoundment system, for porpoise stock assessment research during both these cruises (Coe et al, 1979). Our purpose was to accompany these studies and conduct necropsies on all available porpoise casualties occurring incidental to porpoise stock assessment research and gear technology research.

METHODS

During the course of the two research cruises, a total of 68 porpoise, 49 S. attenuata and 19 S. longirostris (16 eastern and three whitebelly) were available for examination. The number of animals examined, sex, age class, species, and cruise on which they were collected are presented in Table I. All animals were sampled in a fresh state. Due to unavoidable delays in necropsy, it was occasionally necessary to suspend whole porpoise below decks in 35° - 40°F brine wells prior to their removal for examination.

Necropsy technique accomplished the following:

1. Detailed descriptions of any grossly evident lesions and removal of representative tissue samples from both diseased and apparently healthy organ systems.
2. Descriptive accounts on degree of parasitism and apparent related tissue changes.
3. Preservation of representative parasites for specific identification.

4. Detailed accounts on manner and time of death and observable behavior.

All tissue samples were returned to the University of Texas Medical Center for histopathologic examination.

RESULTS

In the assessment of the incidence and extent of the pathologic data obtained we find it necessary to examine and define three major categories of disease:

- I. Naturally occurring disease: disease with no apparent relationship to the tuna purse seine fishery. This category includes parasitism, inflammations of probable infectious etiology, neoplasms, degenerations, etc.
- II. Acute changes: pathologic tissue changes directly related to terminal events, i. e., death due to entanglement or shock within the confines of the purse seine or research gear.
- III. Post-capture mortality (hypothetical): evidence of subacute pathologic conditions which potentially could lead to death subsequent to chase, capture, and backdown release.

Presentation of pathologic findings will be dealt with primarily on an organ system basis. Due to its hypothetical nature the subject of post-capture mortality is organized in a discussion format.

I. Naturally Occurring Disease

As would be expected, disease due to parasitism was the most common and widespread in our sample. Dailey and Perrin (1973) report on the frequency of occurrence of 12 species of parasites from Stenella attenuata and Stenella longirostris in the eastern tropical Pacific.

Due to the limitations imposed by the necessity for rapid examination of animals in the field to prevent decomposition, we were not able to record detailed accounts on occurrence of all species of parasites known to infect these two species of porpoise. We were able to obtain data on frequency of occurrence and disease of five parasite species: Halocercus delphini (lungs); Monorygma grimaldi (serosa); Phyllobothrium delphini (blubber); Strobilocephalus triangularis (lower intestine); and Crassicauda sp. (air sinus and mammary glands).

Our findings on percent occurrence of these parasites are consistent with those of Dailey and Perrin (1973) with the exception of the incidence of the lungworm, Halocercus delphini. The study of Dailey and Perrin (1973) was based primarily on gross observable findings and did not include histopathologic study of infected organs. Histopathologic examination of lung tissue reveals a considerable difference in frequency of occurrence of H. delphini in both species of porpoise, S. attenuata and S. longirostris. (See Table II.)

Heart and Blood Vessels

Evidence of vascular diseases (irregular thickening of walls of small arteries and arterioles) was found in two S. longirostris and two S. attenuata. One of these had small foci of degeneration and scarring of the myocardium. Three instances of minor focal myocarditis and two of "basophilic degeneration" were also found. A few hearts had readily observable small superficial scars.

The presence of typical small vessel disease and patchy scars which suggest an ischemic cause (crossing fascicles) are probably independent of contacts with the fishery. Focal myocarditis of the type seen is not consistent with descriptions of cardiomyopathy in capture disease. Similar scattered foci of inflammation also occur in the kidneys and livers of these animals. Evidence of significant fiber fragmentation or fiber regeneration was not found.

Heart scars in a similar distribution are found in high frequency in beach stranded common dolphin, Delphinus delphis, and Pacific white-sided dolphin, Lagenorhynchus obliquidens, dying of apparently natural causes in coastal southern California waters (Cowan, Walker, and Brownell, manuscript). These animals have no known contact with purse seine fishery operations.

Lungs

The lungs are the organs most frequently and most extensively involved in natural disease processes. A substantial portion of lesions can be attributed to the lungworm, Halocercus delphini, by recognition of viable worms or degenerated fragments of worms in foci of inflammation and scarring; however, not all lesions are proven to be caused by lungworm. The incidence of lung lesions is far greater than this, and in a given animal a lesion with and a lesion without demonstrable worm fragments may be found. It is probable that no adult animal is without scars in the lungs.

Comparison of lesions of obviously differing ages reveals that the host inflammatory reaction is associated with death and ultimate fragmentation of the worm. Some worm fragments mineralize, while others simply become more and more indistinct. Because of this, it is likely that a far higher proportion of lesions are actually caused by worms than can be shown to contain worms.

The evolution of the worm-associated lesion is fairly stereotyped. An acute suppurative reaction occurs in the bronchiole surrounding the worm, and is relatively confined by the structural muscle and cartilage. The bronchiole is occluded and the distal segment, including acini and alveoli, either fill with exudate or collapse. Progression results in necrosis of tissue, including muscle and cartilages and dissolution of the worm, rather than enlargement of the inflammatory focus. Lesions typically remain a centimeter or smaller in diameter, although adjacent lesions may become confluent producing a larger irregular mass.

Debris may be removed through liquefaction, or may calcify.

In extreme examples, metaplastic ossification may result.

In cases in which larvae are present the histopathologic pattern is different. Halocercus delphini is viviparous, with first stage larvae normally discharged into large air passages (Delyamure, 1955). Aspiration may result in their entering the alveoli, where they excite a marked inflammatory reaction. Patches of diffuse pneumonitis are commonly associated with clusters of larvae perhaps because of their small size and ability to permeate the air spaces. The ultimate fate of the larvae is unknown, but the vigor of the tissue reaction against them suggests they succumb quickly.

In addition to lesions demonstrated to be caused by worms, and nodules histologically identical to them, patches of pneumonitis and mucinous edema are not uncommon. The histologic appearance of these indicates they precede the terminal episodes, that is, they existed prior to capture in the net.

Liver

With the exception of two instances of bile duct parasitism by trematodes and a few instances of small scattered foci of inflammation, no chronic liver disorders were recognized. Trematode worms were indicated in sectioned tissue and therefore are not readily identifiable to species. Dailey and Perrin (1973) do not report bile duct parasitism in either S. attenuata or S. longirostris. Tissue reaction to the parasites was typical, localized proliferation of biliary epithelium associated with irritation.

Due to field conditions and the need for preservation of entire stomachs for subsequent food habits research, examination of the gastrointestinal tract was limited to three one meter lengths of intestine. These sections were taken just posterior to the duodenal end, at mid-length, and at the posterior end of the intestinal tract. The only parasitism noted was the presence of the cestode, Strobilocephalus triangularis. This cestode occurred exclusively in the rectal area with the scolex of the worm encapsulated deep in the intestinal wall (described and illustrated in Dailey and Perrin (1973)). Tissue reaction to these worms was that of a mild, localized, low-grade inflammatory response. Aside from parasitism all intestinal tracts were normal.

Air Sinus System

Air sinuses of 67 porpoise were examined. Parasitic infections of the nematode, Crassicauda sp., were encountered in six Stenella attenuata (five two-tone and one speckled phase). Frequency of occurrence of Crassicauda sp. in our sample was similar to that of Dailey and Perrin (1973); it occurred in 33.3% of the calves and 12.5% of the subadults examined. Crassicauda sp. has been demonstrated to be a factor in natural mortality of S. attenuata in the eastern tropical Pacific (Perrin and Powers, in press). To date, the pathologic effects of the adult worm on the host are unknown. Samples of whole, intact, formalin-perfused heads of infected porpoise were collected during this study. Detailed dissection and histopathologic examination of these specimens is still in progress.

Adrenal Glands

One animal, a 175 cm adult S. longirostris, had small multi-focal myxoid neurofibromas in both adrenal glands.

Pancreas

One benign neoplasm apparently of islet cell origin and two instances of pancreatic duct parasitism by trematodes were encountered. The parasites were demonstrated in cross-section of tissues examined and consequently could not be specifically identified. Dailey and Perrin (1973) report two species of trematodes, Campula rochebruni and Zalophotrema pacificum, from the pancreas and hepatopancreatic ducts of these species of porpoise.

Tissue reaction to the trematodes was that of a mild inflammatory response with cellular proliferation typical of localized irritation.

Kidneys

Findings of pre-existing disease include three cases of focal interstitial inflammation, one animal with an infarcted renculus, several instances of isolated glomerulosclerosis and arteriosclerosis, and a single occurrence of a small simple cyst. A neoplasm of tubular epithelial origin was found in an animal which also had a pancreatic tumor.

Reproductive Organs

Parasitism of the mammary glands by the nematode Crassicauda sp. was indicated in sectioned tissue in two sexually mature Stenella attenuata. Host inflammatory response was minimal. Six 1.0 - 1.5 cm diameter vaginal calculi similar in shape, color, and texture to those reported by Sawyer and Walker (1977) were encountered in one 188 cm S. attenuata. No associated chronic tissue inflammation was present.

Spleen

A few animals had splenic changes suggestive of reaction to some infectious agent. These changes consisted of enlargement, softening, and prominent follicular reaction which in one animal was associated with follicular necrosis. These changes do not correlate with either parasitism or evident lung inflammation and do not appear to have any relation to the fishery.

II. Acute Changes Related to the Manner of Death

Ninety-four percent of the porpoise examined drowned as a result of direct contact with either the purse seine or the net enclosure of the whole school research apparatus. With one exception, all mortality in the purse seine was directly associated with individual entanglement, canopy formation during the backdown procedure, or partial net collapse prior to backdown. Mortality occurring in the whole school research apparatus was primarily due to individual entanglement in the net enclosure.

Three S. attenuata (two two-tone and one speckled phase) died of unknown causes. These porpoise were found floating free of the net (two outside the purse seine and one inside ten minutes prior to backdown) and were externally free of net marks. Another porpoise, an adult male S. attenuata, asphyxiated due to laryngeal displacement directly after tagging.

In general, calves and juvenile porpoise of both species involved succumbed quickly when entangled in the net. On the other hand, adults were observed to put up tremendous struggles prior to death due to entanglement.

Lungs

As would be expected, acute tissue changes in the lungs of those animals dying in the purse seine and research gear related to drowning. Drowning in this instance refers to asphyxiation without aspiration of seawater. The resultant violent respiratory movements disrupt lung tissue by producing hemorrhages and alveolar and interstitial emphysema, and disseminate air emboli to liver, pancreas, kidneys, and other organs.

The complex neuromuscular control of respiration in cetaceans is considered to relate primarily to exposure of the blowhole area to the atmosphere (Tomilin, 1948; Ridgway, 1972). This extraordinary degree of lung tissue damage and air emboli undoubtedly relates to struggle and to extremely powerful and violent efforts to breathe against a closed larynx. The nearest morphologic equivalent would be pulmonary laceration and bleeding in divers with the "bends," although mechanisms differ. Pulmonary

alveolar rupture and bleeding is recognized in asphyxiation from many causes (Tedeschi et al, 1977) but embolism resulting from interstitial emphysema is, to the best of our knowledge, unique to these porpoise. Particulate matter suggestive of water aspiration was not found.

Heart and Blood Vessels

Slightly more than half of S. attenuata and two-thirds of S. longirostris were found to have petechial hemorrhages and/or larger focal hemorrhages under the epicardium in the myocardium. There was a slight tendency for the right side of the heart toward the apex to be involved. Patchy congestion occasionally gave the appearance of hemorrhages. Foci of "contraction banding" of both the myocardium and Purkinje fibers were present in many porpoise. It is probable that congestion, petechial hemorrhage, interstitial hemorrhages, and "contraction banding" are merely manifestations of the manner of death, i.e., drowning, asphyxiation, or shock (Tedeschi et al, 1977; Reichenbach and Benditt, 1970).

Adrenal Glands

In general, the adrenal glands are markedly congested, and small interstitial hemorrhages could be found in a few animals. The vascular bed of the adrenal glands is very large, almost cavernous, so that what appears to be massive congestion may in fact be merely filling of the larger channels within physiologic limits. In support of this is the complete lack of any evidence of old adrenal hemorrhages, although in many older animals the adrenal glands are somewhat nodular, suggesting repeated

adaptations to "stress." Aside from this nodularity, no evidence of injury attributable to prior capture or any other stress was found.

Spleen

Severe congestion of the spleen with focal, petechial, or larger hemorrhages on the capsular surface or deep in the parenchyma is a common, almost universal finding. Deep hemorrhages have a loose association with drowning (as opposed to shock death) and all forms of hemorrhages are more common in adult or young adult animals than in juveniles or calves of either species. This probably relates to the observed fact that adult porpoise put up a much more vigorous struggle when entangled in the net.

In the four young porpoise in which splenic hemorrhage was found, no significant variance in cardiac or other disease was recognized. In addition to these splenic hemorrhages, scars in the parenchyma and on the capsular surface were also frequently observed. In these scars residua of blood pigment (hemosiderin) was a common finding. We consider this scar tissue to be evidence of past splenic hemorrhage.

Splenic scars were much more common in S. longirostris of any age (7/19) than in S. attenuata of any age (3/49). Evidence of scarring due to exceptionally large intrasplenic hemorrhage in the remote past was found in one adult S. longirostris. Similar hemorrhages and scars are known to occur in three species of individually stranded porpoise, i. e., Pacific white-sided dolphin, Lagenorhynchus obliquidens, common dolphin, Delphinus delphis, and northern right whale dolphin, Lissodelphis borealis, in southern

California (Cowan, Walker, and Brownell, manuscript). These stranded porpoise had undergone considerable stress due to other chronic disease prior to death.

We consider these splenic hemorrhages to be a manifestation of exposure to markedly stressful events, not only capture in the net, and not relating to direct trauma. They may also be a most extreme form of congestion as part of the general asphyxial reaction (diffuse congestion and petechial and other hemorrhages).

Few porpoise examined demonstrated no hemorrhages, petechia, or pulmonary emphysema and were free of external signs of injury. These were presumed to have died of "stress," a vaguely defined concept in this situation which is thought to be related to a massive cardiovascular reaction to either autonomic discharge or adrenal cortical secretion or both.

"Contraction banding" of myocardial fibers and of cardiac conduction fibers was prominent in some animals. This has been well described in man and a variety of other animals in many fatal situations, including drowning, non-specific injury, panic, etc., and may be considered a response to almost any circumstance drastic enough to produce death. Similar lesions may be produced in the laboratory by catecholamine injections (Reichenbach and Bennitt, 1970; Haft, 1974).

III. Post-capture Mortality (Hypothetical)

This is a speculative category which includes evidence of sub-acute pathologic conditions that could lead to death after a period of time subsequent to chase, capture, and release.

In order for tissue damage to be recognizable, certain changes must take place after the injury. These changes require the passage of time. Our sample consisted entirely of animals that died more or less immediately, i. e., before tissue changes could have taken place. It may be assumed that many individual porpoise are caught numerous times in a fishing season. If this is true, then tissue injury sustained in an earlier capture should be evident on examination following death in a subsequent capture. In the sample available for study (67 porpoise), no such signs of injury were found with the exception of splenic hemorrhage.

The splenic hemorrhages cited were the sole process found that could be related temporally to capture in the nets. Splenic hemorrhage is probably not a consequential lesion in terms of individual well being as the animal can survive to form a scar and die of something else. It is of value to us in that it appears to be a survivable "stress" lesion, an indicator of past events of a gravely threatening but not fatal nature. These lesions are not exclusive to the fishery. They are known to occur in animals stranded singly on the coast of California (Cowan, Walker, and Brownell, manuscript). These porpoise are from stocks and species that would not have been in contact with the tuna fishery.

The phenomenon consisting predominantly of muscle degeneration and necrosis as well as myocardial degeneration and myoglobinuric nephropathy has been found to be widespread among stressed and captured wild terrestrial mammals (Chalmers and Barrett, 1977; Lewis et al, 1977; Harthoorn, 1973). This condition, known variously as "capture disease," "capture myopathy," "stress myopathy," "white muscle disease," etc. is readily recognizable as whitening of skeletal muscle, muscle rupture, or muscle hemorrhage. If present, this condition could be a cause of significant delayed mortality.

Due to recent concern about the possibility of this disease occurring in porpoise as a result of chase and capture in yellowfin tuna purse seine operations, we included a systematic examination of the primary swimming muscles in our survey. The sites selected for examination and sampling are as follows:

1. Longissimus dorsi: from the middle of the muscle
in line with the center of the dorsal fin base
2. Longissimus dorsi: midway between the center of
dorsal fin insertion and fluke notch
3. Hypaxial muscle: midway between center of dorsal
fin insertion and fluke notch

In addition to removal of muscle samples for histopathology, a series of deep longitudinal incisions were made along the entire length of the two muscle masses sampled for purposes of gross examination for evidence of myopathic changes.

Sixty-five animals were examined and sampled. No evidence of myopathy was detected.

CONCLUSIONS

As a result of our studies on the porpoise mortality during purse seine and research operations, we have come to the following conclusions:

1. Natural disease is prevalent in S. attenuata and S. longirostris and relates mainly to parasitism.
2. Death in the net is primarily from drowning. Mortality due to "shock" or "stress" can occur.
3. There is no evidence for "capture myopathy" as an entity in the porpoise sampled.
4. There is evidence of probable stress lesions that may or may not relate to the fishery.
5. We could find no injury or disease process that could be attributed exclusively to the fishery that was not immediately evident as death of the animals in the nets.

We could find no substantial evidence for any "delayed mortality" relating to the fishery. Logic would seem to dictate that an occasional death could so result but we cannot estimate an incidence nor postulate a cause based on the material available to us.

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TABLE I

Summary of S. attenuata and S. longirostris Collected on Cruises II and IVStenella attenuata

Age Class*	Cruise II		Cruise IV		Total	
	Female	Male	Female	Male	Female	Male
Two-tone	5	2	6	3	11	5
Speckled subadult	2	-	-	1	2	1
Mottled subadult	3	1	1	-	4	1
Adult	3	3	3	2	6	5
Adult (pregnant)	4	-	1	-	5	-
Adult (lactating)	6	-	3	-	9	-
TOTAL	23	6	14	6	37	12

*Adopted from Perrin (1970b)

Stenella longirostris

Age Class	Cruise II		Cruise IV		Total	
	Female	Male	Female	Male	Female	Male
Calf	1	-	1	1	2	1
Juvenile	-	-	-	1	-	1
Subadult	-	-	2	1	2	1
Adult	-	2	4	3	4	5
Adult (pregnant)	-	-	2	-	2	-
Adult (lactating)	-	-	1	-	1	-
TOTAL	1	2	10	6	11	8

TABLE II

Comparison of Frequency of Occurrence of the Lungworm

Halocercus delphini with Findings of Dailey & Perrin 1973Stenella attenuata

Age Class	Cowan/Walker		Dailey/Perrin	
	Per Cent	No. Examined (48)	Per Cent	No. Examined (37)
Neonates	-	0	0	5
Calves	37	16	15	13
Subadults	85*	9	15	13
Adults	46	23	0	6

*One animal also had larvae in lungs.

Stenella longirostris

Age Class	Cowan/Walker		Dailey/Perrin	
	Per Cent	No. Examined (19)	Per Cent	No. Examined (10)
Neonates	0	2	-	0
Calves	100	1	20	5
Subadults	100	5	50	2
Adults	90*	11	67	3

*Three animals also had larvae in lungs.

